VOL. L, NUMBER 1 WHOLE NUMBER 418

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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PUBLISHED BI-MONTHLY

January-February, 1956

PRINTED BY
THE UNIVERSITY OF TORONTO PRESS

The Royal Astronomical Society of Canada

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PRINTED IN CANADA

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VOL. L, NO. 1 JANUARY–FEBRUARY 1956 WHOLE NO. 418

THE I.A.U. ASSEMBLY IN DUBLIN AND ACCOMPANYING ASTRONOMICAL EVENTS

AT the invitation of the Irish Government, the Dublin Institute for Advanced Studies and the Director of Dunsink Observatory (Dr. H. A. Brück), the International Astronomical Union held its ninth General Assembly in Dublin from August 29 to September 5, 1955.

Before these meetings began several events of astronomical interest took place. In Hamburg the new Schmidt telescope was dedicated, and a number of astronomers were invited to attend the ceremony. Visiting astronomers who were in London had the opportunity of seeing the Royal Greenwich Observatory at Herstmonceux by invitation of the Astronomer Royal. The Royal Astronomical Society held an evening Conversazione and a special meeting at which the Eddington Medal was awarded to Prof. H. C. van de Hulst for his prediction of the hydrogen 21-cm. emission line as a possible means of studying the distribution of interstellar hydrogen. With a U.N.E.S.C.O. grant through the International Council of Scientific Unions (I.C.S.U.), the I.A.U. organized for specialists in the field of radio astronomy a symposium on this subject at the Jodrell Bank Experimental Station near Manchester. Following the I.A.U. Assembly was a meeting of the Joint Commission of I.C.S.U. on solar and terrestrial relationships, and the Royal Astronomical Society met in Glasgow jointly with the Astronomical Society of Glasgow. Some of these meetings are reported here by different members of the Canadian delegation. Our delegation was headed by Dr. Andrew McKellar of the Dominion Astrophysical Observatory. Others from the same observatory were K. O. Wright and Anne B. Underhill; from the University of Western Ontario: R. W. Nicholls; from the David Dunlap Observatory: John F. Heard, Helen S. Hogg, Donald A. MacRae, Ruth J. Northcott and J. B. Oke; from Queen's University: A. Vibert Douglas; from Saint Mary's University, Halifax: M. W. Burke-Gaffney.

Symposium on Schmidt Telescopes at Hamburg

For the occasion of the dedication of the new Schmidt telescope at the Hamburg Observatory, a symposium was arranged there on August 19 and 20, 1955. Two hundred astronomers from various parts of the world attended these meetings; there were a dozen or more from the United States, and two delegates, Dr. Anne B. Underhill and Dr. J. F. Heard, from Canada.

One part of the proceedings was the unveiling of a plaque honouring Bernhardt Schmidt, the inventor of the telescope which bears his name. Schmidt was an optical technician of the Hamburg Observatory who, in about 1930, conceived the idea of using a correcting plate of complex figure along with a spherical mirror so as to eliminate spherical aberration and at the same time avoid the off-axis aberration which limits the field of a paraboloidal reflector. This ingenious design and his skilful realization of the correcting plate led almost immediately to the first Schmidt telescope, an instrument of 15-inch aperture, whose performance over a five-degree field startled the astronomical world and which is still in constant operation. It was not until after Schmidt died, in 1935, that the details and construction of the instrument were revealed. Since that time many Schmidt telescopes have been built. The results obtained already with these instruments probably justify ranking the Schmidt telescope as the most important instrumental advance in astronomy of this century.

The symposium included a visit to the town of Bergedorf, a beautiful suburb of Hamburg where the Observatory is located. Here the delegates had ample opportunity to inspect the numerous impressive telescopes, old and new, of the Hamburg Observatory. The original Schmidt telescope and the newest 32-inch Schmidt were the most interesting. The latter ranks among the largest of this type in the world; in respect to beauty and convenience it must be the finest. The delegates were particularly impressed with a mobile observing chair with all manner of motorized controls which our host, Dr. O. Heckmann, Director of the Observatory, had dubbed the "astromobile".

The papers which comprised the symposium were given in the Chemistry Amphitheatre of the University of Hamburg. Most were in German, a few in English. They contributed an excellent picture of the current position of the Schmidt telescope in astronomical research, and it was most impressive to realize the tremendous efficiency of these wide-field instruments for an increasing variety of research programmes. Galactic research in particular has made enormous strides through the Schmidt surveys at such observatories as Hamburg, Palomar, Leiden, Vatican, Cleveland, Tonantzintla. And apparently the usefulness of the Schmidt

has not yet been fully exploited; Cambridge and Yale astronomers described the first, very promising, efforts to use the Schmidt for position astronomy—a role hitherto reserved to the astrographic refractors.

The social events of the symposium included a reception by the Senate of the city-state of Hamburg in the City Hall and a closing dinner in the picturesque village of Aumühe in the Saxon Forest.

Visits to the Royal Greenwich Observatory at Herstmonceux Castle

For the benefit of I.A.U. delegates who would be in England the Astronomer Royal arranged two open days, August 19th and September 12th, at Herstmonceux Castle in Sussex, the new home of the Royal Greenwich Observatory. The visitors for the most part travelled by train from London to Eastbourne and were driven by Observatory buses to the Castle for an all-day visit including a fine luncheon in the dining room of the Castle where they were guests of Sir Harold and Lady Spencer Jones.

Herstmonceux Castle itself dates from 1440. In later centuries it fell into disrepair, was restored in the 19th century, later was acquired by the crown and in 1946 designated as a new site for the Royal Greenwich Observatory when observing conditions at Greenwich had become intolerable. Most of the equipment has already been moved from Greenwich and regular observations are being made now at Herstmonceux. However, what impressed the astronomical visitors was the construction of so many domes for new telescopes. On a knoll some hundreds of yards to the east of the Castle is a fine new building incorporating a group of six domes for equatorial telescopes, some existing now and others in the course of construction. Quite separate from these is the site of the planned Isaac Newton telescope, the 98-inch mirror for which is already ground and polished. To the west of the Castle are groups of buildings and domes for solar observations and for position astronomy and the time service. When the construction is completed and the instruments installed the Royal Greenwich Observatory will constitute one of the most impressive astronomical "plants" in existence. It is planned that it will serve not only the large staff of astronomers at the Observatory but also astronomers and students at the British Universities.

The Castle itself houses administrative offices and the beautiful residence of the Astronomer Royal. The visitors, especially those from the United States and Canada, were fascinated by the fine old building, its moat, the beautiful formal gardens and the avenue of 500-year-old chestnut trees. As one German astronomer was overheard to remark, "The castle was built fifty years before America was detected".

Jodrell Bank Symposium on Radio Astronomy

The Symposium on Radio Astronomy, sponsored by the International Astronomical Union, was held at the Jodrell Bank Experimental Station of the University of Manchester in the week preceding the Dublin Assembly, August 25–27. Eighteen countries were represented by about a hundred delegates. Canada was represented by Dr. Donald A. MacRae.

Jodrell Bank is the site of the 250-foot steerable radio telescope which will be the world's largest. Redesign of the antenna to accommodate the relatively short-wave (21 cm.) radiation from interstellar hydrogen has delayed completion of the immense dish, but the gigantic towers, steering machinery, and complex electronic controls were on view.

The first session of the symposium was devoted to a round-up of papers on the hydrogen radiation, beginning with a report by a team of Russian scientists on the first detection of interstellar deuterium, the rare isotope of hydrogen. This report of success in a most difficult observational undertaking (the line is very weak) is certain to encourage further work. Another feature of this session was the presentation of the most recent Dutch surveys at 21 cm. in regions lying in and outside of the galactic plane.

In the morning of the day devoted to galactic structure and studies of point sources (radio stars) a number of authors presented measures, each at a different wave-length, of the intensity of the strong sources in Cassiopeia and Cygnus. It appears that the intensity increases with wavelength, but that there is a region of nearly uniform intensity between 10 cm. and 1 metre. The discussion of how these data could be improved and extended was a highlight of the conference. In the afternoon, the controversial question of the spatial distribution of radio stars was presented. The English observations seem to indicate an increased density of radio sources at remote distances from our galaxy, a situation which evoked considerable discussion by the theoretical cosmologists who were present.

The final day was devoted to the quiet and active sun and to meteors and planets. The solar work dealt with eclipse observations, distribution of emission across the solar disk, polarization of solar radiation, the relation of radio to visual phenomena, and the physical conditions in the sun which govern the emission of radio radiation. It is already apparent that solar physicists must depend as much on radio observations as on optical observations for their basic data. A highlight of the afternoon was the discussion of the recent remarkable announcement that certain localized areas on Jupiter's disk are very strong emitters at radio wave-lengths.

The organizers are to be congratulated for so successfully bringing together observers from all over the world, as well as others primarily interested in the theoretical interpretation of the data being collected, and for providing an opportunity for exchange of information, both formally and informally, in spite of a crowded schedule. The delegates left with a most pleasant impression of the hospitality of the Jodrell Bank Staff, and the beauty of the Cheshire countryside.

The proceedings of the symposium will be published in book form in the near future under the auspices of the I.A.U.

The Ninth General Assembly of the I.A.U.

The ceremonial opening of the Dublin meetings included welcoming speeches by An Taoiseach (the Prime Minister, Mr. Costello), Mr. Eamon de Valera, Mgr. Dr. de Brún, Prof. H. A. Brück and the president of the I.A.U., Prof. Otto Struve.

Among the important decisions of the Assembly was an enthusiastic acceptance of the invitation of the government of the U.S.S.R. and the Russian Academy of Sciences to hold the 1958 General Assembly in Russia. At the request of Dr. J. J. Nassau an official invitation to the I.A.U. to meet in California in 1961 was placed on the agenda of the next Assembly. By acclamation the new president of the I.A.U. is Prof. A. Danjon of France.

The delegates were handsomely entertained. There was an evening reception by the Prime Minister in St. Patrick's Hall, Dublin Castle, part of which dates to the 11th century; an afternoon reception by the President of Eire and Mrs. O'Kelly in the grounds of their Phoenix Park residence; and various receptions for their national delegates given by the several embassies, including one for the Canadians in the home of the chargé d'affaires, Mr. Grant Major. (The photograph shows the Canadian group in front of Mr. Grant Major's home). Excursions were generously provided by the Irish Tourist Board on Sunday, September 4, to Killarney or to Connemara. The Government of Northern Ireland entertained the delegates in Belfast and at Armagh Observatory on September 6. Since over 600 astronomers from 40 countries were in Dublin as well as some 250 members of delegates' families, the scale of preparations for these functions and the meetings can be appreciated.

The Dunsink Observatory, some miles north of Dublin, was open for visitors on four evenings. Among the instruments on exhibition was a very fine photoelectric photometer and some Pye experimental television apparatus for amplifying the light coming through a telescope.

Reception of Canadian delegates by Canadian Chargé d'Affaires, Dublin. Left to right: Mr. Donald W. Munro, Miss Margaret Dowling, Embassy staff; Rev. M. W. Burke-Gaffney, Halifax; Mrs. Munro; Mrs. Bannon; Mr. James Bannon, Visa Attaché; Mrs. Major; Dr. J. F. Heard, Toronto; Mrs. Wright, Dr. K. O. Wright, Victoria; Mrs. Oke; Mrs. Nichols; Dr. Helen S. Hogg, Toronto; Dr. R. W. Nichols, London; Mrs. MacRae; Mr. T. Grant Major, Chargé d'Affaires; Mrs. McKellar; Dr. Anne Underhill, Victoria; Dr. Donald A. MacRae, Dr. J. B. Oke, Miss Ruth J. Northcott, Toronto; Dr. A. McKellar, Victoria; Dr. A. Vibert Douglas, Kingston. (Photograph by courtesy of *The Irish Times*.)

So many meetings were running concurrently nearly every morning and afternoon with frequent prolongations into evening sessions that no one delegate could do more than attend a small fraction of them. Some of the delegates from Canada played active parts in the Commissions of Radial Velocities, Variable Stars, Star Clusters, Spectrophotometry, Stellar Photometry, Physical characteristics of planets, satellites, comets, Radio Astronomy. In this report only a few of the highlights can be mentioned.

The most extensive single item on the agenda was a symposium on non-stable stars, which included invited papers on almost every kind of non-stable star. The Russians have always been particularly interested

in such stars, and they were responsible for almost half of the papers in the symposium. These dealt with the T Tauri stars, novae, Wolf-Rayet stars and close binary stars. An interesting paper was given by Dr. G. H. Herbig of the Lick Observatory, who showed a photograph of a T Tauri region taken in 1954 with two more star-like condensations than had been present in 1947. This appears to support the general view that stars are being formed even now in the T Tauri regions. Canada was represented at this symposium by a paper by Dr. A. McKellar and Dr. R. M. Petrie on the eclipsing binary 31 Cygni which consists of a giant K-type star and a small B-type star. They showed that mass motions of 10 to 20 km./sec. occur in the atmosphere of the supergiant star. Dr. M. Walker reported on photoelectric observations of old novae. He has found that most of them fluctuate in light, some of them over intervals of only a few minutes.

Discussions of the astronomical applications of photoelectric image tubes occupied another important symposium. Such a tube has a photosensitive surface and an arrangement for accelerating the emitted electrons so that they may impinge on a photographic plate. Then, when light from the telescope falls on the photosensitive surface, the photograph is actually made by the accelerated photoelectrons. The possible gain in sensitivity is about 20 to 50 times over the usual photographic process. During this symposium the participants reported on experiments with such tubes, emphasizing the many difficulties involved. While the tubes are far from perfect, noteworthy advances have been made. Fine photographs of Mars taken with such a tube were shown.

Another symposium was concerned with a comparison of the large-scale structure of the galactic system with that of other stellar systems. The Dutch astronomers reported on their 21-cm. radio observations of hydrogen. On the basis of these observations they have constructed a very fine map of part of our galaxy which shows four spiral arms. Dr. Baade remarked on the absence of blue stars within 3 kiloparsecs of the centre of M31. In a paper presented on behalf of Dr. Ambartsumian the high number of multiple galaxies was noted. Exception was taken to the explanation of NGC 1275 as two colliding galaxies, but Dr. Baade affirmed strongly that this was the only tenable conclusion. Dr. Lindblad spoke on the evolution of spiral arms—are they a later stage of what began as rings, an inner circular ring and an outer elliptical ring, which after six hundred million years would break up and merge to give rise to spiral arms? Dr. Mayall reported on the estimated periods of rotation of barred and ordinary spirals and of elliptical systems as being mostly from 74 to 100 million years with one as high as 250 million years.

At the Dublin congress, as at other I.A.U. congresses, the symposia were really the icing of the cake, so to speak. Of greater importance were the smaller meetings of specialists in the various fields of research where efforts were made to plan the direction of astronomical research in the next three years and to detail the degree of international co-operation needed. To accomplish this end without in any way hindering individual enterprise is the real role of the I.A.U. If enthusiasm and complete lack of discord are criteria, then the role of the I.A.U. was admirably accomplished at Dublin.

Glasgow Meeting of the Royal Astronomical Society

The Royal Astronomical Society, the University of Glasgow and the Astronomical Society of Glasgow co-operated to arrange a two-day astronomical programme immediately following the Dublin General Assembly on September 7th and 8th. About a hundred of the delegates and their guests took advantage of this opportunity to visit Glasgow and attend the meetings and other events which were arranged. Canadians who attended were Dr. and Mrs. Andrew McKellar of Victoria and Dr. J. F. Heard of Toronto.

The astronomical features were a colloquium on the formation of stars, a popular lecture on the evolution of stars by Dr. Otto Struve and an ordinary meeting of the Royal Astronomical Society which included the presentation of contributed papers. Other events in which most of the visitors took part were visits to the optical works of Messrs. Barr and Stroud, and bus tours to the Trossachs and to Loch Fyne. As well, there were several pleasant social gatherings including a tea in the College Club tendered by the Astronomical Society of Glasgow and a reception by the University in Bute Hall.

ENDEAVOUR – REACHING FOR THE STARS*

By Joseph A. Pearce

It is interesting to recall that in all probability Captain George Vancouver was the first white person to walk across our campus, pausing to admire the panorama of the sea and the fir-clad snow-capped mountains. No other University in Canada has such a magnificent view.

On Wednesday, June 13, 1792, Vancouver landed on this plateau, which he named Point Grey after his friend Captain George Grey, and he correctly determined the latitude. He was here again on Friday, June 22, 1792. It was his practice to take soundings and compass bearings and to make sketches of the land from a small open boat, and, on this occasion, rounding the point, busily engaged at 5 o'clock in the morning, he was surprised to see two Spanish vessels, of whose presence in these waters he had been ignorant. He landed and had breakfast with two Spanish captains.

Fellow Graduates, I refrain from asking you as a final test at the University to name these Spanish captains. I wish to read to you the exact wording on the splendid Historical Sites and Monuments Board of Canada plaque, located about 200 yards from here:

The Last Spanish Exploration

In commemoration of the first friendly meeting of the British and Spaniards in these waters. Near this place, Captain George Vancouver, on June 22nd, 1792, met the Sutil and the Mexicana under Captains Galiano and Valdes, the last Spanish exploring expedition on what is now the British Columbia coast. The commanders exchanged information, established mutual confidence, and continued the exploring together. It was dawn for Britain, but twilight for Spain.

I need not remind you that Vancouver's exploration of our Coast was one of the most detailed and accurate surveys in the annals of the British Admiralty. Where did he get his schooling? He enlisted under Captain James Cook at the age of 13 years and, until Cook's death, served under him as an able-bodied sailor and later a midshipman. Experience was his only school and Cook his principal teacher. When Cook returned to England in 1776 from his second great voyage of discovery to the South Pacific, which added so many possessions to the British Crown, he was elected a Fellow of the Royal Society of London. Because he was the

*An address given at the University of British Columbia Congregation, May 16, 1955. On this occasion the honorary degree of D.Sc. was given to Joseph Algernon Pearce, and that of LL.D. to Francis James Burd and Robert Wellington Mayhew.

first to show that the dreaded disease, scurvy, could be conquered, having lost only one man out of 118 in over 1000 days at sea, he was awarded the Copley Medal. What an inspiring leader Cook must have been—astronomer, surveyor, navigator, practical physician. Along with a commanding personal presence, the ability to make important decisions promptly and wisely, and perseverance quite extraordinary, he possessed other qualities no less useful to his work. He won the affection of those who served under him by his unselfish care of them, by his sympathy and by his kindness.

Let us then note that in Cook and Vancouver we have an example of the master-pupil linkage, so often observed in the history of the biological and the physical sciences.

While Vancouver was exploring our coasts, in England William Herschel—the father of sidereal astronomy—was making the first great survey of the Milky Way. With telescopes of his own construction, he enthusiastically explored the galaxy of stars and communicated his amazing discoveries to the Royal Society in a series of annual papers.

He discovered the orbital motions of double stars, and compiled catalogues of hundreds of these physical systems. He discovered and minutely described literally thousands of nebulae, the island universes of the philosopher Immanuel Kant. He named a new planet after his King, calling it the Sidus Georgium. George III was greatly pleased and appointed Herschel his private astronomer at a salary of £200 per annum, thus establishing a dim precedent for the salaries of astronomers.

The Royal Society elected Herschel a Fellow and awarded him a medal, which spurred him on to greater endeavours.

Vancouver named the neighbouring strait the Gulf of Georgia after George III, but history is silent as to whether this interested his Royal Highness.

From the beginning, Herschel had an increasing purpose in his work, the construction of the first model of the sidereal universe. His method was to make systematic sweeps with his telescope, estimating the brightnesses and counting the number of stars within his telescopic field. Again and again he repeated his observations, until his star counts were accurate. After some years of observing he had accumulated such data for 3400 different areas of the sky. He concluded that while space appears limitless, the number of stars in our stellar system is finite, and that the system had a flattened form, somewhat like a wheel, or, as he said, a grindstone. He placed the sun near the centre of the galaxy, and he estimated the diameter of the system as 7500 light-years. (That is, Herschel believed that light which travels at the amazing speed of six

million million miles in one year would require 7500 years to cross the diameter of the galaxy.)

Although he could not prove it, Herschel was convinced that the great stellar system of hundreds of thousands of millions of stars was in rotation about some distant centre. This great astronomer was nearly two centuries ahead of his time, for the problem of the rotation of the galaxy remained one of the important problems in sidereal astronomy throughout the last century. It was solved only in recent decades.

This is the 40th Convocation of the University of British Columbia. If Captain George Vancouver ushered in the dawn of British Columbia in 1792, I think I may be pardoned if I claim that the sun arose 40 years ago when an Act of Parliament created this University. By a happy coincidence, the Dominion Astrophysical Observatory is of the same age as the University, for in 1915 the Provincial Government, ever generous toward learning and research, purchased a suitable site on Little Saanich Mountain near Victoria, and built a splendid road one and a half miles long to the summit, as a gift to the Federal Government so that the then world's largest telescope could be located in this Province. We have been, and I trust we always will be, grateful to the Provincial Government for their support. The great dome was constructed in 1916, and in May 1918, after four and one half years of grinding and testing the large parabolic mirror, the 45-ton telescope was assembled and put into use. Dr. John Stanley Plaskett was our founder and first director, an eminent Canadian scientist whom this University honoured in 1925.

During these 40 years the University has steadily developed and grown; today, I believe, your fine library contains some 300,000 volumes. During these years, we have accumulated 48,000 stellar spectra. By analyzing these spectra, the stars are made to reveal their hidden secrets, but only after much labour. These amazing spectrograms furnish answers to many of the questions a mathematical physicist might ask: What is the distance of the star? What is its temperature, 100,000° or 2000°? How large is it? What is its mass, 70 times the sun or one-twentieth the sun's mass? What is the chemical composition of its atmosphere? What atoms and molecules do the spectra reveal? How fast is the star rotating on its axis, and with what speed is it travelling through space? The greatest contribution of the Observatory has been in the field of stellar motions. During this half century some twelve observatories in Europe, Africa and America have collaborated in determining the velocities of the stars through space, and approximately one-third of the 15,000 velocities known have been measured by the astronomers at Victoria.

I now wish to return to the subject of the rotation of the galaxy—our

most important astronomical research. Since William Herschel's day, the problem of the distribution of the stars in space has been attacked by many astronomers, notably by Wilhelm Struve, Argelander, Gould, Gylden, and in this century by Seeliger, Schwarzschild, Charlier, and Kapteyn. The famous Dutch astronomer, Kapteyn, published in 1922 a second model of the universe, which according to him had a diameter of 55,000 and a thickness of 11,000 light-years. A few years later Shapley from a 10-year study at the Mount Wilson Observatory, of globular clusters symmetrically distributed about the galaxy, concluded that the diameter was as great as 200,000 light-years. A new approach to this problem was urgently desired.

For ten years, Dr. J. S. Plaskett and I collaborated in a study of the motions and distributions of the high-temperature stars. We obtained over 3,000 spectra of stars so distant that their light required 4,000 to 5,000 years to reach the earth. The velocities of these stars provided convincing proof of the dynamical structure of the galaxy. Arranging our stars into groups of known galactic position and distance from us, the mathematical solutions indicated the direction of the centre to be at galactic longitude 327°, in the distant star clouds of Sagittarius. Our sun and the cluster of naked-eye stars was found to be 30,000 light-years from the centre.

The star groups closer to the dynamical centre were observed to be travelling with faster orbital velocities, while those more distant than the sun were found to be moving with slower orbital velocities. Our results confirmed the differential rotation theory proposed by Lindblad of Sweden and Oort of Leiden.

The final dynamical constants deduced are interesting to recall: The diameter of the galaxy was found to be 90,000 light-years, our sun being located at approximately two-thirds of the distance from the centre of the system, at a point where the circular velocity is 275 km./sec., or 170 miles per second. It was not difficult to weigh the galaxy, the mass being 160,000,000,000 suns, this mass being divided between the 100,000,000,000 lucid suns and the dark interstellar gaseous and solid matter. Our sun and the neighbouring naked-eye stars perform one revolution about the centre in about 220,000,000 years. This is one of the more interesting results of our research, for if we take the age of the earth as 4,500 million years—a fair estimate—it will be realized that during our whole geological history we have made but 20 revolutions about the galactic centre. Sometime during the twelfth revolution, life arose on the earth, and during six or seven revolutions slowly evolved through the long archaeozoic and palaeozoic eras from unicellular life to amphibians and fishes. During the last revolution, the dinosaurs, pterodactyls, and archaic mammals, the

ancestors of our modern animals, arose, flourished and vanished. During the last one million years, the pleistocene era, the advent of man occurred, while our sun was moving only two degrees in its great orbit about the centre of the galaxy.

Such, briefly, are the high-lights of a research in which we weighed the galaxy, determined its dimensions and found our distance from the centre of the great stellar system. In recent years not only optical methods but also the new techniques of radio astronomy have been concentrated on this problem, and the remarkable observations secured in Australia and in Europe within the past two years have conclusively demonstrated the spiral arms and structure, which were previously beyond detection. The observations now being secured at Victoria will, in a few years' time, answer other questions on phases of this great dynamical problem.

The history of astronomy is the fascinating story of man discovering his place in the mysterious universe; it is the story of continually receding horizons, with the ever-advancing sidereal explorations and, in consequence, the liberation of our minds from ignorance and from those superstitions that we have inherited from the childhood of our civilization.

Notwithstanding a warning that I should not preach to the graduates, I venture to give you in closing an exhortation. I referred to Cook and Vancouver simply to tell you that which you know full well, that no great work is ever accomplished without sustained endeavour. It was so in the days of ancient Egypt, it is true to-day, and so may it be forever.

I congratulate you upon your spendid degrees, and wish you every success. How fortunate you are to be devoting your lives to medicine, biology, forestry, and the physical sciences in this day of so many wonderful opportunities. Achievements in these fields come early, but I warn you to start now, as you should make a real contribution within the next 20 years. We recall that Cook was killed at the age of 40, and that Vancouver died at the same early age from hardships endured on his great explorations.

I give you a formula for success: Remember the names of these vessels commanded by Cook and Vancouver—the Endeavour, the Resolution, the Adventure, the Discovery.

Face your problems, and indeed, life itself as an adventure; labour resolutely; strenuously and persistently endeavour; and you cannot fail to make discoveries.

HEAT FLOW MEASUREMENTS IN PERMAFROST AT RESOLUTE BAY, NORTHWEST TERRITORIES*

By A.D. Misener,[1] P. C. Bremner[2] and J. H. Hodgson[3]

ABSTRACT

During the summer of 1950–53 drilling operations were carried out at Resolute Bay with the object of determining the temperature gradient in the underlying rock at depths up to 1000 feet. Difficulties in drilling were encountered due to the presence of permanent frost and because of caving formation in the rock strata. To overcome the permafrost the water used in drilling was preheated but even with this precaution the drill rods were frequently frozen in the hole. Techniques were eventually developed to overcome most of the difficulties encountered.

Several holes were completed ranging in depth from a few feet to 650 feet. Temperature-measuring elements were installed at five-foot intervals to a depth of 100 feet and at 50-foot intervals to a depth of 650 feet. Cores were taken at 50-foot intervals and used to determine thermal conductivity.

Analysis of temperatures measured in the holes indicates a temperature gradient at depth of 2.16°F. per 100 feet. The mean thermal conductivity of the cores has been determined as $7.3 \pm 0.7 \times 10^{-3}$ cal./cm./sec./deg. C. Combining these two measurements leads to a heat flow of 2.9×10^{-6} cal./cm.^{2}/sec. This is about twice the value hitherto accepted as normal for the sea level crust.

An unexplained anomaly exists in that temperatures near the surface are higher than would be expected from the gradient at depth.

Introduction

In 1948 the Dominion Observatory sent P. C. Bremner to Resolute Bay to investigate the possibility of installing a seismograph station there. It was desired to place the instrument piers on rock, and since there are no rock outcrops in the vicinity of the living quarters it was decided to take a small diamond drill with which to determine overburden thickness at various points.

When Mr. Andrew Thomson of the Meteorological Division, Department of Transport, heard of these plans he suggested that temperature-measuring elements be placed in any holes drilled, with a view to determining temperature fluctuations within the soil. These temperature-measuring elements were supplied by the Meteorological Division and

Contributions from the Dominion Observatory, vol. 1, no. 19. Published by permission of the Acting Deputy Minister, Department of Mines and Technical Surveys, Ottawa.

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an array of them was successfully set out, at various depths within the overburden and at various heights above it. Weekly temperature readings have been made with this set of elements since the time of their installation in August 1948.

These observations showed the expected type of annual temperature fluctuation in the overburden and confirmed that below 5 or 6 feet the ground never warmed above freezing. However, they also indicated that, at depths below those experiencing annual fluctuations, the temperature *decreased* as the depth increased. This is contrary to all observations elsewhere. It was obvious that this decrease could not continue indefinitely and at some depth the normal behaviour, i.e. increasing temperature with increasing depth, must become apparent. Somewhere then, there would be a minimum in temperature.

Thus the initial work left many interesting questions unanswered. To what depth did the seasonal variations of temperature penetrate? At what depth was the minimum temperature reached? How thick was the permanently frozen layer? In order to answer these questions it was proposed that an attempt be made to drill two holes, one to a depth of 100 feet, the other to a depth of 1000 feet, and that temperature-measuring elements be placed at five-foot intervals within the former hole and at 100-foot intervals within the latter. The close array near the surface would permit a careful investigation of seasonal variation, while the deep hole would allow a definition of the temperature gradient to depth. It was further proposed that the hole be core-drilled as much as possible, in order to make rock samples available for geological study and for conductivity measurements.

The proposed programme had many points of practical importance to recommend it. In recent years there has been a quickened interest in the arctic both for the military problems which it poses and for the mineral potential which is becoming apparent. Engineering problems connected with permafrost will assume increasing importance, and a programme which would cast light on the temperatures and thickness of this permanently frozen layer would have much interest. In particular, if a technique could be found for successful drilling through frozen ground the programme would have filled an important purpose.

Aside from these practical aspects the work had considerable interest for pure geophysics, for it offered the opportunity to measure heat flow in the arctic regions. The amount of heat flowing toward the surface of the earth is one of the few directly measurable quantities which can throw light on conditions within the earth's interior. It is important that this quantity be measured at as many points, and at as widely dispersed

points, as possible; the opportunity to make a measurement in the arctic was therefore welcomed.

The simple programme which had originally been planned had to be modified many times, and four summer seasons instead of the proposed one were required for its completion. Indeed the 1000-foot hole was never completed, but the programme did succeed in placing temperature-measuring elements at five-foot intervals to 70 feet, at ten-foot intervals from there to 100 feet, and at 50-foot intervals from 100 feet to 650 feet. Duplicate elements were placed at some depths to provide a check on the temperatures measured, and cores were taken at 50-foot intervals from which thermal conductivities could be determined.

Detailed papers have already been published on the drilling programme (Bremner, 1955) and on the interpretation of the temperature and conductivity data (Misener, 1955). Readers are referred to these earlier papers for more specific information than is given here.

Several different agencies have co-operated in the work. The Meteorological Division of the Department of Transport was responsible for matters relating to personnel—the hiring of drillers, the provision of board and lodging and similar matters—while the Dominion Observatory, Department of Mines and Technical Surveys, provided the drilling equipment and supplies. P. C. Bremner was in charge of the operation, during the first two years as an employee of the Dominion Observatory, during the last two on loan from a commercial drilling company. The United States Weather Bureau supplied the temperature-measuring cables and provided some financial assistance. Additional financial assistance came from the National Research Council through the Associate Committee on Soil and Snow Mechanics. The Air Transport Command of the Royal Canadian Air Force provided emergency transportation for much heavy equipment.

The Drilling Programme

In order to understand the difficulties which extended a programme originally planned for one summer into one that required four summers for its completion it is necessary to appreciate two facts, first that in diamond drilling it is necessary to circulate water or some other fluid to wash the cuttings back to the surface, and second that the temperature in permafrost is below the freezing point of water. It turned out, in fact, that the permafrost temperatures at Resolute Bay were much below freezing, a temperature of about −13°C. being reached at 100 feet. Even at 650 feet the temperature was still about seven degrees below freezing.

A brief description of a diamond drill may be helpful to those readers

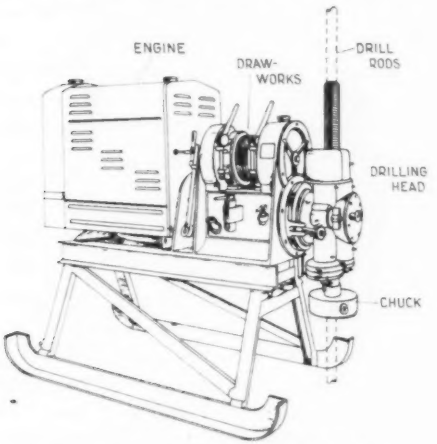

FIG. 1—Diagram of a diamond-drill rig.

who have never seen one. The complete drilling rig consists of a drill, such as that shown in figure 1, with a tripod bearing a sheave at its apex mounted above it. A wire rope passes from the draw works of the drill up through the sheave on the tripod, and may be used to raise or lower the drill rods. The drill itself consists of four essential parts, an engine to supply power, a transmission to carry this power to the drilling head, the draw works already mentioned and the drilling head. The drill pipe, as indicated in the figure by a broken line, passes through the drill head, entering through the feed screw at the top and emerging through the chuck at the bottom. In lowering the drill rods into the hole they are let down by means of the draw works until the bottom of the hole is reached and then, the set screw in the chuck being tightened, are advanced by means of the feed screw.

The drill rod is hollow and terminates at its lower end in the bit, which does the actual cutting of the rock. There are various sorts of bits, some of which preserve a cylindrical core, others which grind up the rock to a fine powder. In any case water is always pumped down the drill rods. This water, emerging through holes in the bit, clears away the cuttings and flushes them to the surface up the outside of the drill rods. It was this circulating water which provided the difficulty in permafrost drilling, for under normal circumstances it would freeze, resulting in the sticking of the drill rods.

There are various ways in which this problem can be combated. One

is to use oil or antifreeze as the drilling fluid in place of water. This might be feasible under normal circumstances, but at Resolute Bay the rock is rather badly fractured, which results in considerable loss of fluid. Difficulties of supply made the use of special fluids impractical. Instead, the device was used of heating the water before it was pumped down the hole. If the initial temperature was high enough, the water could be pumped to the bottom of the hole and returned to the surface before it froze. The balance was a ticklish one however, for if anything occurred to impede the circulation or to cause a break-down of the drill, the water might fall below the freezing point and the rods be seized. The hot water actually tended to increase equipment difficulties, for it destroyed pump and rod lubricants and imposed extra strain on hoses and on pump gaskets.

Difficulties were experienced almost from the beginning of the programme and as a result the original programme was modified in several ways. In particular the idea of placing an 18-element cable in a hole drilled to a depth of 1000 feet was postponed in favour of placing a number of single-element cables in shallower holes. This was done because the single-element cables were less bulky and on the principle that it was better to achieve a number of limited objectives rather than to stake everything on the single hole.

Within this modified programme, single-element cables were placed in five holes ranging from five to fifty feet, in holes 300 and 500 feet deep, and in a hole sloping at an angle of 45° under the ocean to a depth of 115 feet. The original multi-element cables were placed in holes 100 feet and 650 feet deep. This makes a total of ten holes in which cables were placed. A total of 21 holes were attempted, and in the remaining eleven of these serious difficulties were encountered. In most cases of difficulty bits and drill rods were lost, and it was necessary in several instances to fly in extra equipment to Resolute Bay.

There were three inter-related factors contributing to these drilling difficulties. The first—the low temperatures in the permafrost—has already been mentioned. A second derived from the fractured nature of the rock, which had a tendency to jam the rods. For example, two holes were lost in succession at depths of about 675 feet, apparently due to caving formations. The third difficulty had to do with the size of the equipment and the size of the hole drilled, and modified the other problems.

Diamond drills may be obtained to drill holes of various sizes, from a minimum of 1.46 inches to a maximum of 3.5 inches. For any hole size, drills rated for various depths can be obtained. In selecting the drill for

the project, the problem of transportation to Resolute Bay was uppermost in everyone's mind; consequently drill pipe and bits for the minimum hole size were selected, and a drill with a capacity for 1000 feet of this hole was purchased. This was a mistake. The drill itself had too little reserve, and the small hole gave rise to many difficulties.

The most serious of the difficulties arising from the small hole were due to the impeded water circulation. With small clearance between the drill pipe and the wall of the hole, an adequate circulation of water could only be maintained by using very high pump pressures. This required the use of high pressure hoses because a hose failure with the water near the boiling point would have scalded the drillers. Even by maintaining high pressure it was often not possible to circulate water fast enough to keep the frost driven back from the hole, and this in turn meant that in the event of a breakdown there was almost no time before the pipes were frozen.

These difficulties were overcome to a large extent by the following method. Whenever a tendency for impeded circulation became evident by increased pump pressures, the hole would be reamed to a much larger size, and water would be circulated for a long time before drilling recommenced. This overcame most of the difficulties associated with the small hole, but only at the price of much delay.

Although the maximum depth reached was 650 feet, it was felt that a substantial contribution was made towards solving the problem of drilling in permafrost. There seems little doubt that with heavier equipment the projected depth of 1000 feet could have been reached. As we shall see in the next section, a very good value of the temperature gradient was obtained and the additional expense necessary to reach the greater depth would probably have been unjustified.

Temperature Measurements and Heat Flow

Temperature readings for each element installed during the programme have been made systematically from the time each installation was made. These readings have been made by the successive Seismological Station operators, and the data have been collected by the Meteorological Division. The data fall logically into two groups, those from the shallower holes where the daily or seasonal fluctuations make themselves felt, and those from the greater depths to which the surface effects do not penetrate.

A preliminary discussion of the shallow readings has already been given by Thomson and Bremner (1952). They showed that at a depth of 8 inches the ground temperatures followed the daily and seasonal

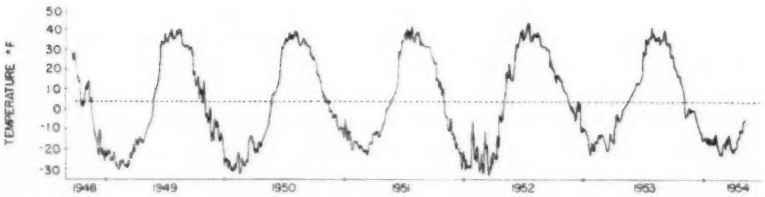

FIG. 2—Temperature variations at a depth of eight inches, 1948–1954.

variations with very little time lag. At a depth of 60 inches the daily fluctuations had been wiped out, while seasonal variations recorded at this depth with a delay of from one to two months.

More data have accumulated with the passage of time, and figure 2 shows the variation of temperature at a depth of eight inches. The dashed line in figure 2 indicates the mean temperature of 4.0°F.

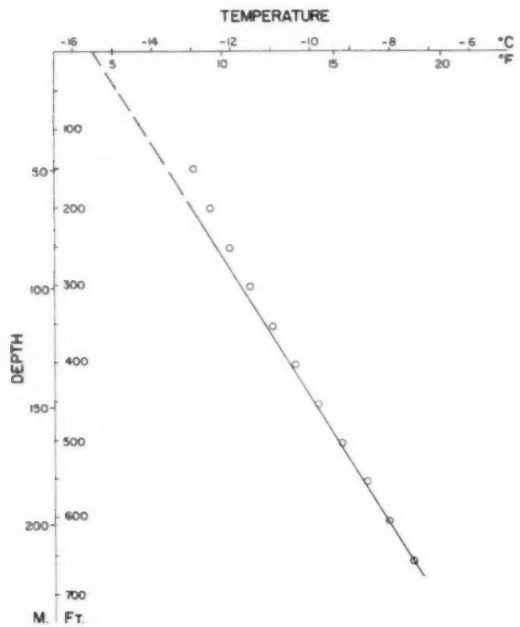

FIG. 3—Temperature variation with depth. The line corresponds to the gradient of 2.16°F./100 feet.

The essential temperature information for the deep holes is contained in figure 3 which gives the relationship between temperature and depth. Below 300 feet the curve is essentially a straight line, from which the temperature gradient of 0.0394°C./metre or 2.16°F./100 feet may be determined. This temperature gradient is very much higher than the values of 0.5°F. to 0.9°F. per 100 feet found in the southern part of the Canadian Shield (Misener, Thompson and Uffen, 1951), but compares well with the average value of about 2.0°F. per 100 feet found in permafrost in Alaska (MacCarthy, 1952). It appears that temperature gradients are higher than normal in the permafrost areas of North America.

Having established the temperature gradient we may use it to estimate the thickness of the permafrost. This works out to be 1280 feet, with an uncertainty of ± 10 feet. This uncertainty arises because the thermistors used to measure the temperatures were not calibrated for pressure. It is known (Misener and Thompson, 1952) that the resistance of a thermistor changes due to change in pressure, even though there is no change in temperature. In the present case the correction is likely to be the same at all depths since the pressure, most of which is due not to the hydrostatic head but to the pressure of the freezing ice, will be the

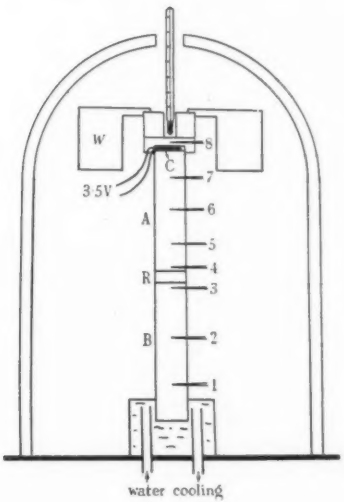

FIG. 4—Schematic diagram of the apparatus used to measure conductivities (after Benfield).

same at all depths. Consequently, while the individual temperatures may be in error by a few tenths of a degree, the gradient is almost certainly correct.

In order to determine the heat flow it is necessary to know not only the temperature gradient but also the thermal conductivity of the rocks in which the gradient was measured. It has already been mentioned that cores were taken at 50-foot intervals from zero to 650 feet. These cores were sent to the University of Western Ontario, where they were used to determine an average thermal conductivity. The conductivities were measured by a divided bar apparatus, originally described and calibrated by Benfield (1939). The apparatus is shown in schematic form in figure 4. It consists of two brass rods, A and B, between which the rock sample R is inserted. Heat enters the system through the small heating coil C, passes down through bar A, sample R and bar B, and is carried away by the water cooling at the base.

Temperature gradients throughout the system are measured by thermojunctions, indicated by numbers in the figure. Once a steady state has been reached, and assuming no lateral heat loss, the heat flowing through rod A is the same as the heat flowing through the sample R and through rod B. The product of temperature gradient and conductivity is a constant for any part of the system so that, by measuring the gradients across the sample and in the rods, and assuming a value of the conductivity of brass, we can determine the conductivity of the rock sample. The conductivity of the brass rods is known from earlier tests in which quartz disks of known conductivity were used to calibrate the instrument.

One difficulty was met in determining the thermal conductivities. In normal operation the sample R is cut to have the same diameter as the bar. This could not be done in the present case because the cores cut by the diamond drill were already smaller than the bar. Experiments were conducted using pyrex disks of various diameters to investigate the effect of small diameter samples, and with these experiments as a guide it was possible to correct for this factor. The final value of conductivity obtained was $7.3 \pm 0.7 \times 10^{-3}$ cal./cm./sec./deg. C.

Multiplying this value of conductivity by the temperature gradient of 0.0394°C./metre we obtain the heat flow value of 2.9×10^{-6} cal./cm.^{2}/sec. This value is considerably greater than that reported for any other region, and is more than twice the value now accepted as normal for the sea level crust. We have already noted that the temperature gradient obtained at Resolute Bay was abnormally high; the high heat flow is a reflection of this. It will be recalled that a high temperature gradient was also noted

in permafrost in Alaska. There are no measurements of conductivity to accompany the Alaskan temperature measurements, but it appears probable that the heat flow in Alaskan permafrost is also abnormally high.

There is one other interesting fact to be noted about the temperatures. If the temperature gradient curve shown in figure 3 is continued back to the surface it indicates a surface temperature of 4°F., which is very close to the mean air temperature shown in figure 2. Actually, as indicated in figure 5, the temperatures measured at shallow depths lay slightly off this line in 1950, but by 1954 there was a change in the gradient indicating that the surface was warming up. Combining the extrapolated "deep-hole" gradient, with the 1950 and 1954 measurements, and assuming a steady rate of heating, the rise in temperature must have begun sometime in 1948.

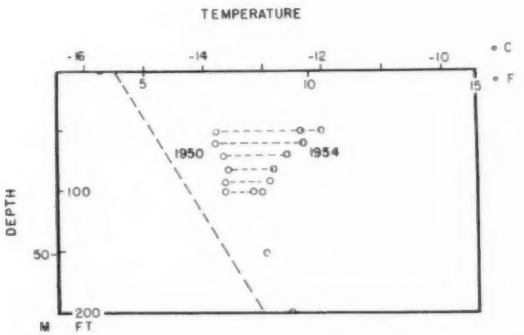

FIG. 5—A comparison of the near-surface temperatures taken in 1950 with those taken in 1954. The dashed line indicates the temperature gradient established by the deep-hole measurements.

No reasonable explanation has suggested itself for this reversal. Whatever has caused the heating began two years before the start of the drilling programme, and, at least on the basis of the data in figure 2, appears not to have affected the mean surface temperatures. The explanation of these phenomena is obscure but it is hoped that the accumulation of observations during the next few years together with a more detailed analysis of the data may eventually yield an explanation.

In the meantime three things have been accomplished by the programme. A technique has been developed for diamond drilling in permafrost, an understanding has been obtained of the relationship between

near-surface permafrost temperatures and the air temperatures, and it has been established that the temperature gradient and heat flow at Resolute Bay are much higher than normal for more southerly latitudes.

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VARIABLE STAR NOTES

American Association of Variable Star Observers

By MARGARET W. MAYALL, *Recorder*

The 44th Annual Meeting of the A.A.V.S.O. was held on the week-end of October 21–23 in Springfield, Massachusetts, at the invitation of Mr. Leo Otis, the Director of the Springfield Museum of Natural History. Local arrangements were made under the capable chairmanship of John A. Welch, with the assistance of our Secretary, Clinton B. Ford. Springfield proved to be a near-ideal spot for a meeting, with a hotel, attractive Council room, lecture hall and planetarium, all within a stone's throw of each other.

The officers elected for the year 1955–56 are:

President:	Cyrus F. Fernald	Council Members:	Ralph N. Buckstaff
1st Vice President:	Richard W. Hamilton		Dorrit Hoffleit
2nd Vice President:	Ralph N. Buckstaff		William A. Miller
Recorder:	Margaret W. Mayall		Virginia M. Nail
Secretary:	Clinton B. Ford		Edward G. Oravec
Treasurer:	Percy W. Witherell		John J. Ruiz
			Domingo Taboada
			John E. Welch

Twenty-five new members were elected to the A.A.V.S.O., including one life, two sustaining (one a transfer from annual), and 22 annual, as follows:
Hans Arber, *Philippines*; Ray Berg, *Indiana*; Stephen Bieda, Jr., *California*; Columbus Astronomical Society, *Ohio*; Harold R. Colvin, *New York*; J. Wilson Corriston, *Pennsylvania*; Bede A. Dahmus, *North Dakota*; Robert Deemer, *California*; Carl Ward Faber, *Brazil*; Walter S. Fish, *Quebec*; Winthrop H. Hall, *New Jersey*; David O. Halvorson, *New Jersey*; John J. Hunt, *Pennsylvania*: Ronald A. Javitch, *Quebec*: George Lovi, *New Jersey*; Cleofas Ismael de Medeiros Uchoa, *Brazil*; Robert W. Miller, *Florida*; Morgan Monroe, *Arizona*; Nilehi Astronomical Association, *Illinois*; Frederick Pilcher, *Kansas*; John Polgreen, *New York*; Robert Rawlings, Jr., *Arkansas*; Emil A. Sill, *New York*; Doneley H. Watson, *Ohio*; Flora J. Watson, *Ohio*.

The Chairmen of all committees reported on a very active year. Mrs. Margaret Beardsley told of 84 occultation reports received during the year. She mentioned, particularly, the work of Mr. Charles Good and the Montreal Centre group, and Messrs. Cleaver (New Haven), Elias (Athens), and Sill (New York). Harry L. Bondy's report of the Solar Division is published in the Solar Division Bulletin.

The Chairman of the newly-formed Photoelectric Photometer Committee, Lewis J. Boss, is preparing a brochure of information on the construction and use of a photometer for amateurs. John E. Welch, Chairman of the Telescope Loan Committee continues hard at work trying to clear up the records on the many instruments owned by the Association. Richard W. Hamilton reported for the Chart Committee that more than 3600 blue print identification charts were mailed out during the year, and several new variable star fields have been added.

The Recorder reported that during the year 1954–55, 144 observers from 20 countries contributed 64,990 observations in 709 reports. Nearly one-third of the observations were made by 35 observers outside of the United States. Regular reporting of observations is always appreciated, and 31 observers sent in reports for 10 months or more during the year.

Nineteen observers made more than 1000 observations during the year. Reginald P. deKock was again in first place with 5,977, followed by Edward Oravec with 4,843. The others, in order, were Hein, Skaritka, Anderson, Fernald, Aronowitz, Elias, Cragg, Adams, Hartmann, Solomon, Renner, Taboada, Overbeek, Darsenius, Peltier, Ford, and Venter.

More than 30 of our observers have telescopes of 7 inches or larger. We are holding these people responsible for getting observations at or near minimum light for the fainter variables. During the past year they have co-operated very well. Five observers: Robert Adams, Harry Bull, Claude Carpenter, Thomas Cragg, and Paul Watson have had observations of 14.0 or fainter on each report sent in during the year; and Adams and Cragg sent reports each month. Five more observers, Demetrius Elias, Clinton Ford, C. J. Renner, Michiel Overbeek and S. C. Venter had observations 14 or fainter on more than half of their reports. Charles Aronowitz, A. R. Ball, Per Darnell, Edward Halbach, Giovanni Lacchini, Ronald Royer, and Leonard Solomon contributed a few fainter-than-14 observations, but not enough to admit them to the "Inner Sanctum." Nineteen other observers have had observations 13.0 or fainter. If this work continues, the bottoms of the light curves will be as well observed as the tops.

In addition to the regular type of observation of the variables, some of the observers are carrying out special programmes on the flare stars, by keeping a constant watch for a stated period of time. The rapidly varying star AE Aquarii was watched for 28 minutes by Bull, for 4 hours by Overbeek, and for 1 hour and 28 minutes by Watson. UV Ceti was watched one hour and 14 minutes by A. W. Mount, 1 hour and 30 minutes by Overbeek, and 1 hour by Venter. Darsenius has kept watch on two known flare stars: 9 hours 44 minutes on DO Cephei, and 10 minutes on WX UMa; and 44 minutes on a possible flare star, BD+55° 1823. The reports were all negative, that is, no flares, but the observations are statistically very important.

A very interesting group of papers was presented at the meeting. Dr. Carl L. Stearns, Director of the VanVleck Observatory, Wesleyan University, gave the Friday evening lecture, "Trigonometric Parallaxes." He surveyed the work done in the past on various methods of determining stellar distances and told of the errors that are bound to occur, even with the most modern equipment today. After Dr. Stearns' talk, Mr. Frank Korkosz, Director of the Seymour Planetarium, gave a special demonstration with his projector.

Abstracts of the papers, edited by R. Newton Mayall, will be published by the A.A.V.S.O. Their titles follow:

"Method of Using Stonyhurst Charts", Ralph Buckstaff.
"Theory on Pulsating Stars," Maxwell Kimball.
"Some Glimpses of Astronomical Activity in Australia," Martha Carpenter.
"A Bright Meteor in High Magnification," Gunnar Darsenius.
"What are Solar Flares, and How can Amateurs Observe Them," Harry Bondy.
"The Observing Group of the Amateur Astronomers Association," William Glenn.
"Questar," Cyrus Fernald.

"Variations in Total Visual Light for R Cyg and RT Cyg," Clinton Ford.
"Another Look at Algol," Jeremy Knowles.
"Report on the IAU Meeting," Margaret Mayall.
"EB 120 Leporus", Edward Oravec.
"A Color-Free Solar Telescope," David Rosebrugh.
"English Observatories," Charles Federer.

The feature of the Annual Dinner was Dr. Shapley's presentation of his "Highlights of the Year." He began by saying that the highlight for the A.A.V.S.O. was the completion of the Campbell volume "Studies of Long Period Variables", containing mean light curves for nearly 400 long period variable stars. As usual, he emphasized that the following order is not significant.

Highlights of Astronomy, 1954–1955.

Among the Highlights in and near the astronomical field during the past year I select the following as worthy of mention on this occasion.

1. The announcement that the American Government would sponsor fiscally and scientifically the MOUSE—the artificial tax-supported satellite that is designed as a part of the operations of the International Geophysical Year (1957–58). This small body, it is planned, will sail around the earth, reporting as it goes on what this planet does to missiles and meteorites at an altitude of two or three-hundred miles. Probably several different satellites will be tried out in the course of this adventure with multiple rocketry. We note that this project is concerned with peaceful knowledge rather than with military advantage.

2. Detection of the Thunderbolts of Jove, or some equally potent electric phenomenon on the surface of Jupiter by Dr. B. F. Burke and Dr. K. L. Franklin of the Carnegie Institution of Washington, through the use of a radio telescope located at Seneca, Maryland. The disturbing effect, accidentally found in the course of work on a sky survey, has been verified by Australian observers. This is but one of the many remarkable developments of the year in the field of radio astronomy, among which are the Milky Way explorations at Leiden, Sydney, Ohio State University, and Harvard; the building of several large "dishes" in half a dozen countries, and the approach toward completion of the 250-foot radio telescope at Manchester, England.

3. The finding of the star of smallest known mass by Dr. Sarah Lee Lippincott of the Sproul Observatory of Swarthmore. This object, Ross 614B, which has a mass of only one-twelfth that of the sun, is the fainter component of a dwarf reddish double star. Discovered through its wavy proper motion, this record-holder has been actually photographed separated from its primary by Baade with the Hale Telescope.

4. The raising again of the question as to the ownership of the upper air and the right-of-way of outer space. The Boston Museum of Science has been selling stars, clusters, and even galaxies, and issuing formal deeds thereto. (For example, I own the Hercules globular cluster!) But who owns the atmosphere at the altitude where the Mouse will run with a speed greater than 200 miles a minute?

5. Conclusion of a 50-year research programme by many Harvard astronomers on variable stars of the Magellanic Clouds. The analysis included 3,000 variable stars, three-fourths of which are Cepheids. For 1,220 of them, periods and light curves have been determined.

6. The definitive identification by Dr. Walter O. Roberts and his associates at the High Altitude Observatory of the University of Colorado and by Dr. David Layzer

of Harvard of the important yellow line in the spectrum of the solar corona as due to Calcium XV—that is, to calcium atoms that have only six of their twenty electrons remaining under the high ionizing conditions of temperature and density on the sun's uppermost atmospheric layers.

7. Report by E. C. Slipher of the Lowell Observatory on the 10,000 excellent photographs of Mars in red, yellow, and blue light, made by him with the Michigan Observatory telescope on Naval Hill, Bloemfontein, South Africa, during the recent favourable opposition; also a report by Dollfus, father and son, of France, on their photoelectric observations made from a balloon 45 miles above the earth's surface, of the small moisture content of the Martian atmosphere.

8. Appearance of the first installment of the two-colour star and galaxy atlas, made with the 48-inch Schmidt telescope under the auspices of the National Geographic Society and the Mount Wilson-Palomar Observatory, with important technical assistance from the Research Laboratories of the Eastman Kodak Company.

9. The occurrence on June 20 of this year of a solar eclipse with the greatest duration of totality, 7 minutes 7.8 seconds, since June 717 A.D., 1,238 years ago. It will be nearly 200 years before this record will be broken, when again the eclipsing moon will be near perigee as the earth nears aphelion.

10 An explanation by C. F. von Weizsaecker of the reason for sphericity of globular clusters and their freedom from interstellar dust and gas. His theory involving the cleaning of clusters by orbital passages through the Milky Way's nebulosities, is that dust and gas have been cleaned out by frequent passage of the clusters through nebulosities in the Milky Way.

Nova Search Summary: Nova search areas were scrutinized by the following 6 observers for the number of area-nights indicated. The name is followed by three figures, these are the area-nights observed in the months of August, September, and October, 1955: DeLorne Diedrich 1, 3, 3; George Diedrich 9, 14, 9; Paul Diedrich 0, 6, 2; Earl Milton 28, 0, 0; Beaufort Ragland 24, 10, 20; Louis Rick 22, 24, 12.

Observations received during September and October 1955: In September, 64 observers sent 6,498 observations, and during October, 73 submitted 7,011, a total of 13,509 for the two months.

Observer	September		October		Observer	September		October	
	No. Var.	No. Ests.	No. Var.	No. Ests.		No. Var.	No. Ests.	No. Var.	No. Ests.
Adams, R. M.	63	163	50	154	Kelly, F. J.	13	36	13	13
Albrecht, W. B.	...	...	3	3	Kimball, M.	53	54	26	26
Ancarani, M.	...	...	17	27	Knowles, J. H.	11	37	...	...
Anderson, C. E.	220	568	175	301	de Kock, R. P.	131	361	131	528
Aronowitz, C.	134	223	148	270	Kofeod, R.	4	10	3	6
Ball, A. R.	...	...	24	39	Lacchini, G. B.	51	115	55	93
Beidler, H. B.	59	134	35	66	Lawrence, M.	...	...	4	4
Berg, Ray	...	...	7	9	Maran, S. P.	59	86	103	239
Bicknell, R. H.	17	114	...	...	McPherson, C. A.	34	37	20	20
Boutell, H. G.	8	24	7	14	Mebius, W. G.	...	...	10	20
Breckinridge, J.	12	34	15	47	Melville, E. C.	13	13	...	...
Buckstaff, R. N.	20	67	12	33	Miller, R. H.	7	7	21	21
Carlisle, J. H.	2	3	3	6	Miller, W. A.	9	10	...	...
Charles, D. F.	...	...	29	48	Montague, A. C.	50	73	17	29
Chiabotta, R.	2	2	...	...	Morgan, F. P.	4	7	8	20
Cleary, Carl	...	...	7	18	Neff, J.	...	...	8	15
Cleary, Nelson	...	...	3	11	Oravec, E. G.	155	381	186	531
Cragg, T. A.	223	244	269	292	Pearcy, R. E.	5	5	8	8
Culp, C.	12	94	19	186	Pearlmutter, A. E.	...	...	15	16
Darnell, P. B.	3	21	3	9	Peltier, L. C.	40	187	42	197
*Darsenius, G. O.	30	341	37	206	Peters, J. G.	6	7	...	...
Deemer, R.	6	10	...	...	Pilcher, F.	...	...	9	25
Diedrich, DeL.	2	2	2	3	Pivonka, R. J.	2	2	2	3
Diedrich, G.	2	9	11	21	Renner, C. J.	...	...	162	218
Elias, D. P.	101	840	101	265	Richards, M.	...	...	4	6
Erpenstein, O. M.	4	5	6	16	Rick, L.	2	2	...	...
Escalante, F. J.	59	59	...	...	Ricker, C. L.	2	2	...	...
Fernald, C. F.	198	282	211	390	Rizzo, P. V.	31	48	30	47
Ficonetti, R. J.	15	21	...	...	Robb, S.	7	7	10	10
Ford, C. B.	120	123	194	202	Rosebrugh, D. W.	15	102	13	99
Gaustad, J. E.	24	31	10	10	Royer, R.	14	20	8	11
Gemberling, R. H.	23	25	13	18	Schultz, G. W.	43	68	33	52
Glenn, W. H.	11	27	9	25	Segers, C. L.	...	...	15	30
Goldenblatt, P. P.	108	200	60	116	Skaritka, P.	157	400	179	603
Goodsell, J. G.	2	2	3	3	Solomon, L.	129	192	154	329
Halbach, E. A.	...	...	48	61	Taboada, D.	38	38	37	37
Hales, LaV.	5	6	...	...	Thomas, M. A.	...	...	2	4
Halvorson, D. O.	18	18	20	20	Venter, S. C.	...	...	97	286
Hartmann, F.	129	134	166	182	Walko, K.	3	6	4	4
Hein, G.	134	261	98	249	Waskiewicz, T.	1	1	...	...
Hiett, L.	...	...	7	18	Weaver, J. P.	4	5	...	...
Houston, F. B.	...	...	4	4	Weitzenhoffer, K.	...	...	10	10
Howarth, M.	...	...	17	17	Yamada, T.	51	112	21	58
James, R.	...	...	27	34					

*Plus 2 hours 34 minutes DO Cephei.

A.A.V.S.O. Headquarters,
4 Brattle Street,
Cambridge 38, Massachusetts,
November 1955.

METEOR NEWS

By Peter M. Millman, *National Research Council, Ottawa*

1955 Perseid Observations in Regina

At the opening of the new observatory of the Regina Astronomical Society last June their President, Mr. John Hodges, said that it was now time for the Society to convert from a construction company to an active observing group making contributions to astronomy. They have made a very auspicious step in this direction by taking full advantage of three nights of good weather at the Perseid maximum in 1955. Of course meteor observing is not a new game to the Regina group but the programme reported here was more successful than any of their previous meteor shower campaigns.

Both visual and photographic recording was carried out on the grounds of the observatory in Regina on the nights of Aug. 10/11, 11/12, and 12/13. Visual observers were divided into two groups with four teams in each group. The groups alternated, each observing for an hour at a time, and the teams were assigned to watch the four quadrants of the sky. In general meteors were timed, identified as Perseid or Non-Perseid, and the magnitudes estimated. Special observers plotted the bright meteors which stood a chance of appearing on the camera exposures. Other members were appointed as timekeepers, recorders, stenographers, and last but by no means least, operations officers in charge of refreshments at the Club Centre. John V. Hodges directed the programme.

Those taking part in the visual observations are listed below in alphabetical order:

L. Antonini, Miss Betty Antonini, G. H. Bahr, Miss Alice Coyle, G. Cumming, Mrs. Jo Dunn, Don Ganshorn, Mrs. Lucie Gilbert, Mrs. Francis Haglund, Bernard Haysom, Mrs. Jean E. Hodges, John V. Hodges, J. C. Hodges, Gerald Hodges, Miss Fay Hodges, Allan Irwin, Len Lekivetz, Edwin Lindenbach, George McNeely, Harold McIntyre, Robert Nesbitt, Clayton Punshop, H. G. E. Rhodes, Leslie Sherman, Dr. George Sotiroff, George Story, Robert Sykes, Gordon Thompson, Johan Toews, Ronald Torrie, William Vallis, Miss Alison Watson, Alvin Winestock, Milow Worel.

The numbers of meteors recorded by the visual party are listed in Table I, which is self explanatory. The numbers of meteors seen each hour, centred on times taken every 20 minutes, were reduced to values for a standard of six observers by the usual factors (see *Jour. R.A.S.C.*, vol. 28, p. 139, 1934). These standard hourly rates are plotted in figure 1. It will

TABLE I
NUMBERS OF METEORS OBSERVED

Date (1955)	M.S.T. (hrs.)	Perseids	Non-Perseids	Average number of observers
Aug. 10/11	2100–2400	73	44	10
Aug. 11/12	2100–2400	216	81	9
Aug. 12/13	2100–0100	333	90	11
	Totals	622	215	

be seen that these reached fairly high values even though the period of observation did not extend on to the early morning hours, at which time the highest rates normally occur.

The weather was generally clear throughout the three nights of observation. The last quarter moon rose half an hour before the close of the observing period on the first night and there was slight auroral activity in the NNW between 2300 and 2400 hrs. on this same night. The Perseid shower exhibited approximately equal activity on the last two nights with possibly a few more meteors appearing on the middle night when the results are compared hour for hour. This would place the 1955 maximum

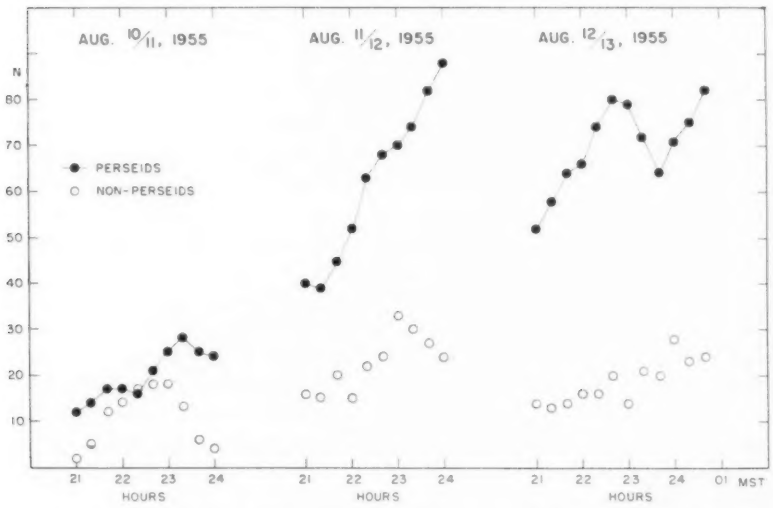

FIG. 1—The hourly rates of meteors reduced to six visual observers, N, plotted against Mountain Standard Time.

for Regina about half way between the last two observing periods but slightly nearer the central night. This corresponds to a solar longitude of 139°.1 while the mean for the Perseid maximum taken over a number of years is 139°.2 (see *Jour. R.A.S.C.*, vol. 48, p. 194, 1954) a very close agreement. Apparently the Perseid meteors in 1955 were well-behaved and normal.

The visual observers estimated all magnitudes to the nearest half magnitude. While this may be a little difficult for those just learning to observe meteors, experience at Ottawa over the last eight years has demonstrated the value of training all observers to estimate to the half magnitude. Nothing is lost by this procedure and often much is gained. Since all nights presented much the same observing conditions the magnitude estimates have been totalled for the three observing periods and are listed in Table II. These estimates were very consistent. Mean Perseid magnitudes for the three nights were 2.5, 2.7, and 2.6 respectively, while for Non-Perseids they were 3.1, 2.9, and 3.1. As will be seen from Table II the overall mean for the Perseid meteors was 0.4 magnitudes brighter than for the Non-Perseids. A slight tendency to estimate whole magnitudes in preference to half magnitudes is evident in the magnitude distribution.

TABLE II
MAGNITUDE DISTRIBUTIONS

Mag.	−2	−1.5	−1	−0.5	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	Totals	Mean Mag.
P	2		2	1	20	20	50	24	106	73	115	102	69	23	13	2	622	2.64
NP			2	1	2	3	8	8	24	21	44	39	45	14	3	1	215	3.03

Co-operating with the Regina group, Gordon Bitney and Gerald Bitney observed and plotted 43 meteors from 1047 to 2400 hrs. On Aug. 12/13 at B-Say-Tah, lat. 50° 07′ N., long. 103° 51′ W.

The photographic programme at Regina was carried out by Gordon R. Thompson and J. G. McNeely, working with John V. Hodges. Four cameras were used with focal lengths of 50, 101, 105 and 105 mm. respectively and aperture ratios F/4.5. A 30° objective prism was mounted on one camera. The film used was Eastman Super XX and Eastman Super Pan Press, developed in Promicrol developer. Exposures totalling approximately 8 hours were made on the three nights. One spectrum and two direct meteor photographs were obtained.

The spectrum is of a Perseid which appeared at $23^h\ 37^m\ 40^s$ M.S.T., Aug. 12, 1955, and was estimated as of visual magnitude −1 with a train lasting

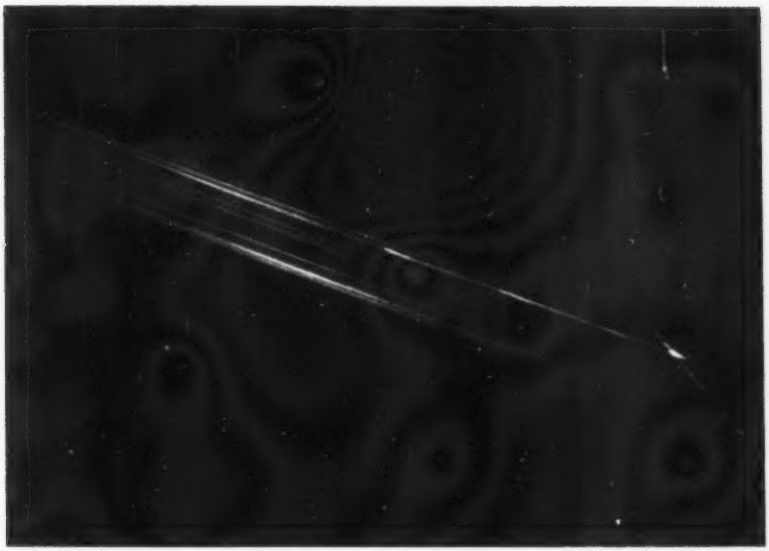

FIG. 2—The spectrum of a Perseid meteor at $23^h\ 37^m\ 40^s$ M.S.T., Aug. 12, 1955, photographed at Regina on Eastman Super XX emulsion. The violet end of the spectrum is reproduced at the top and the meteor moved from left to right.

7 seconds. The spectrum is in good focus and shows excellent definition, considering the low dispersion of 870 A./mm. at $H\gamma$. It has been reproduced in figure 2. As far as I know this is the first meteor spectrum secured by an amateur group in Canada and the Regina Astronomical Society is to be congratulated upon their success.

Examination of the spectrum indicates that it is a typical Perseid spectrum (see *Nature*, vol. 172, p. 853, 1953) with the atomic lines of calcium I and II, magnesium I and II, sodium I, iron I and silicon II prominent. Twenty-three lines have been measured and, using the H and K lines of ionized calcium and the D lines of sodium as standards, wavelengths were computed. These are listed in Table III, together with the multiplets identified as making the chief contribution to the strength of each line. A photometric study of the spectrum has not yet been completed but an indication of relative intensity of the lines has been listed qualitatively.

This spectrum shows a feature noted in quite a number of other meteor spectra. The ionization builds up along the path. While at the beginning of the trail neutral sodium, magnesium and calcium are re-

TABLE III

WAVE-LENGTHS MEASURED IN PERSEID SPECTRUM

Wave-length (angstroms)	Line strength		Multiplets making major contribution
	Early part of trail	Final burst	
3719	weak	medium	Fe I (5) (21)
3736	weak	medium	Fe I (5) (21)
3757	weak	medium	Fe I (5) (21)
3831	medium	strong	Fe I (4) (20) Mg I (3)
3858	weak	strong	Fe I (4) (20)
3890	very weak	medium	Fe I (4) (20)
3933	strong	very strong	Ca II (1)
3970	strong	very strong	Ca II (1)
4036	very weak	weak	Fe I (43) Mn I (1)
4074	very weak	weak	Fe I (43)
4130	very weak	weak	Fe I (43) Si II (3)
4226	medium	weak	Ca I (2) Fe I (42)
4267	very weak	very weak	Fe I (42)
4313	very weak	very weak	Fe I (42)
4376	weak	weak	Fe I (2) (41)
4424	weak	very weak	Fe I (2)
4480	weak	medium	Mg II (4) Fe I (2)
5183	medium	weak	Mg I (2)
5374	very weak	very weak	Fe I (15)
5720	very weak	very weak	Na I (6)
5892	strong	medium	Na I (1)
6146	medium	very weak	Na I (5)
	medium	very weak	Si II (2) N_2 bands
6410	edge of band		

latively strong, at the terminal burst ionized calcium and ionized magnesium have strengthened considerably as compared to the neutral elements.

This spectrum illustrates very well what can be accomplished in meteor photography with relatively modest camera equipment. Such a photograph is a definite scientific contribution and it is to be hoped that we will see other results of this type achieved by the various amateur observing groups across Canada. In conclusion I should like to thank the Regina observers for the neat and efficient way in which their observations were organized and tabulated. This helped greatly in preparing the material for publication.

NOTES AND QUERIES

Ireland's Ornament: Agnes Mary Clerke

At the ceremonial opening of the I.A.U. in Dublin Mr. Costello referred to two Irishmen who brought fame to Ireland in astronomy, Sir William Hamilton and Lord Rosse. However, he did not make mention of Ireland's great ornament: Agnes Mary Clerke.

Agnes Mary Clerke (1842–1907) was born in Skibbereen, in the county of Cork. Her father was a bank manager with a classical education and an interest in astronomy. He had his daughters educated at home with private tutors. When Agnes was fifteen she thought there was need for a history of astronomy in English, and began to write one herself. She did not leave Skibbereen until she was nineteen, when her father was transferred to Dublin. Two years later, her father was transferred again, and the family moved to Cobh.

It was from Cobh that Agnes left for Italy, at the age of twenty-five, with her elder sister, Ellen Mary. It was at Florence that she wrote her "Copernicus in Italy", which, when published in *The Edinburgh Review*, made her name. She was asked, tentatively, to write the article on Copernicus for the ninth (1875–1889) edition of the *Encyclopedia Britannica*. Afterwards she was commissioned to do for the encyclopedia articles on Brahe, Flamsteed, Galileo, Halley, Humboldt, Huygens, Kepler, Mayer, and others. It was this commission which was chiefly responsible for her settling in London with her sister (who had already contributed poems, essays and stories, in English to English periodicals and, in Italian to Italian periodicals.). Agnes found the facilities of the reading room of the British Museum ahead of all aids to research in her native Skibbereen or in her family home at Cobh.

In 1885, was first published her often-reprinted *A History of Astronomy in the Nineteenth Century*. In 1888, she finished her last article for the *Encyclopedia Britannica*, five pages on the *Zodiac*. That same year she accepted the invitation of Sir David and Lady Gill to South Africa, and spent three months at the Cape Observatory. On her return, she published *The System of the Stars* (1890), and, in 1892 was awarded the Actonian prize by the Royal Institute. In this same year, 1892, she published *Familiar Studies in Homer*.

In 1895, she published *The Herschels and Modern Astronomy*, and was responsible for the bulk of *The Concise Knowledge of Astronomy* (1898) for which she wrote sections I and III, with A. Fowler doing section II, and J. E. Gore section IV.

In 1903 she was elected, together with Lady William Huggins, an honorary member of the Royal Astronomical Society, and published her *Problems in Astrophysics.*

Her last book was *Modern Cosmogonies* (1906), and her last article, the article on Astronomy for the *Catholic Encyclopedia,* vol. II (1907). She died one year after her sister Ellen, who was two years older than her. Lady Huggins wrote a loving appreciation of the two sisters.

Agnes Mary Clerke had a freshness of style redolent of the breezes of Skibbereen. Her quiet sense of humour might have been considered daring in other Victorian women, but Mayfair made allowances for Agnes, because she was Irish.

M. W. Burke-Gaffney

The Artificial Satellite

At the November meeting of the American Astronomical Society in Troy, N.Y., Dr. Fred L. Whipple presented a paper outlining the astronomical significance of the artificial satellite, whose launching is planned for the International Geophysical Year 1957–58. Behind the project are the American organizations, the National Science Foundation, and the National Academy of Sciences, as well as the United States Department of Defence which will handle the technical problem of putting the satellite in its orbit by multi-stage rockets.

The first satellite probably will be about the size of a basketball moving around the earth in a period of 1½ hours with a velocity of some 18,000 miles an hour in an orbit whose perigee distance is at least 200 miles. The inclination of the orbital plane to the earth's equator is not yet decided. Knowledge of the upper atmosphere is still too meagre to predict the air resistance at an altitude of 200 miles, so that estimates of how long the satellite will remain in its orbit before spiralling rapidly towards the earth vary from hours to years. The present plans call for the launching, at suitable intervals, of as many as ten satellites, of which half may actually get settled in their orbits.

Instruments in the satellite could radio to earthbound scientists much useful data about cosmic rays, micrometeors, the earth's magnetic field, and ultra-violet, X-ray, and corpuscular radiation from the sun. Even optical observations of the satellite from the earth will contribute invaluable information. The satellite will be seen best just before it enters

the earth's shadow from a place where the earth is in twilight. The visual magnitude is expected to be between 5 and 7; thus the satellite just may be seen by the naked eye. Accurate positional observations, which are extremely essential, will be difficult because of the fast motion of the body. For the Palomar 48-inch Schmidt telescope as well as for the Baker Super-Schmidt cameras the limiting magnitude for such a rapid motion is about 6. Once there are enough observations to predict the orbit a telescope could be moved to follow the satellite. It is unlikely that any one station will have the opportunity to determine a good position more than once a week. Such observations could greatly improve our knowledge of the distribution of matter inside the earth, the distance between the continents, the variation of the earth's period of rotation, and the density of the higher atmosphere.

DONALD C. MORTON

TELESCOPES FROM WAR SURPLUS LENSES

Having access to a large quantity of war surplus objective lenses of superb quality and correction, but of short focal lengths, I was faced with the problem of obtaining performances equal to the standard f/15 telescope. The results I obtained were better than hoped for.

The standard telescope with an f/15 lens has a short eye relief with high powers that makes it difficult to use if one must wear glasses. Using a war surplus lens with an aperture of 2½ inches and a focal length of 18 inches it was possible to get the same power as in the normal f/15 telescope by using the method illustrated. The magnification is obtained by the eyepiece separation; this is actually a compound microscope and erects the image. In fact, I have used a Bausch and Lomb 40× shop microscope as the eyepiece with my 3-inch refractor with excellent results.

It is to be noted that in using such a lens erector the longer focal length eyepiece lenses provide larger eye relief and greater comfort to use, and at the same time the arrangement allows high magnification to be attained.

I have recently built a number of refractors using this system. The smallest is but 17 inches in length, 1¼ inches in diameter and can be separated in the middle for carrying in a pocket; yet it has 60× magnification and excellent definition.

W. T. PATTERSON

Ross Walter Marriott, 1882–1955

Ross Walter Marriott was born in Paxton, Illinois on December 30, 1882, and died at Hahnemann Hospital in Philadelphia on October 19, 1955. Ross Marriott entered the University of Indiana in 1902, where he obtained the Bachelor's degree in 1906. He came to Swarthmore with the late Dr. John A. Miller, when the latter came to Swarthmore College in 1906 as professor of Mathematics and Astronomy. He received the Master's degree at the University of Pennsylvania in 1911. He taught Mathematics at Swarthmore College for forty-six years, as an instructor (1907–1910), assistant professor (1910–1922), associate professor (1922–1927), and professor of Mathematics and Astronomy (1927–1952). Marriott took an active part in making the adjustment of, and early observations with the Sproul 24-inch refractor after it was installed in 1911.

From 1923–1932 Marriott participated with Miller in the Swarthmore Eclipse expeditions, and due to his zeal and care Swarthmore College possesses a collection of fine coronal photographs. In the Director's office of the Sproul Observatory hangs an oil painting by the late Owen D. Stephens (well-known artist of astronomical subjects) of Miller and Marriott studying a solar eclipse photograph.

The fruits of his long period of service in the teaching profession, and his valuable collection of eclipse photographs remain as a monument to Ross W. Marriott of Swarthmore College.

Peter van de Kamp

Newsletters from the Centres

For some time the editors have been receiving "Skyward" from the Montreal Centre, in which the varied activities of this energetic group are described. The "News Bulletin" of the Toronto Centre has recently been augmented by bulletins from the Study and Observation Group. These bulletins summarize talks given by members of the group, and cover such varied topics as an introduction to the lunar surface and a rather thorough discussion of orbits.

The most recent bulletin to be received at this office is from the Edmonton Centre. It is called "Stardust", and since the issue at hand is vol. 2, no. 2, the publication has been running for some time. It is evident that serious and valuable observations of sun-spots, variable stars and occultations are being carried out in Edmonton.

The activity shown by these bulletins is most encouraging and it is hoped that it will spread to other centres.

The Editors

NOTES FROM OBSERVATORIES

David Dunlap Observatory

Observing conditions during the summer and autumn have been poorer than average. Much of the observing time has been devoted to obtaining spectrograms of dispersion 33 A./mm. for a luminosity study of the brighter components of 115 visual binaries being carried out by Mr. Bakos. These stars have also been measured photometrically by Mr. Bakos with the 19-inch telescope.

All five senior members of the Observatory staff were able to attend the ninth General Assembly of the International Astronomical Union in Dublin during September, namely Dr. Heard, Dr. MacRae, Dr. Helen Hogg, Miss Ruth Northcott and Dr. Oke. At the Congress Dr. Hogg was named President of the newly-formed Sub-commission on Variable Stars in Globular Clusters, and Dr. Heard was invited to replace Dr. J. A. Pearce upon his retirement from Presidency of the Sub-commission on Standard Velocity Stars.

Dr. MacRae was a delegate to the Symposium on Radio Astronomy at Jodrell Bank, Manchester, August 24–27, and Dr. Heard attended the Symposium on Schmidt Telescopes at Hamburg, August 18–20, and the meeting of the Royal Astronomical Society in Glasgow, September 7–9.

Dr. Oke was married on August 20th to Nancy Sparling of Toronto. Since their return from a wedding trip in England, Ireland and Scotland, Dr. and Mrs. Oke have been residing in North Toronto.

Dr. Peter Wellmann of the Hamburg Observatory, Germany, has joined the Observatory Staff for the present session. Dr. Wellmann's family have come to Richmond Hill with him, and Mrs. Wellmann is assisting in the measurement of spectrograms of the stars of the Alpha Persei Cluster, a programme undertaken recently in co-operation with the Hamburg Observatory.

Miss Olga Boshko, on leave of absence from the Dominion Observatory, is enrolled in the School of Graduate Studies to proceed to an M.A. degree in astronomy. She has undertaken a study of the space motions of a thousand stars recently studied for radial velocity at the Observatory.

Dr. Oke conducted a colloquium on the subject of Stellar Luminosities at the University of Rochester on November 7th.

Dr. MacRae represented the Observatory at the meeting of the Ameri-

can Astronomical Society in Troy, N.Y., November 9–12. He presented papers submitted by Dr. Heard and himself.

Dr. Wellmann visited the Perkin Elmer Corporation in Norwalk, Conn., to discuss problems in connection with the Armagh-Dunsink-Harvard telescope at the Boyden Station in South Africa. Dr. Wellman had visited South Africa in 1955 to serve as a consultant in the matter of the re-organization of the Boyden Station.

A recent visitor to the Observatory was Dr. G. P. Kuiper of the Yerkes Observatory. He spoke to an Astronomical Colloquium on "The Early History of the Moon" and addressed a joint meeting of the Royal Canadian Institute and the Toronto Centre of the Royal Astronomical Society of Canada on "The Formation of the Planets".

The first instalment of the National Geographic–Palomar Observatory Sky Atlas has been received at the Observatory. This instalment consists of 200 prints, 14 inches square, made from the red and blue sensitive Schmidt plates of 100 of the fields. The whole survey consists of 879 fields 6½ degrees square, and prints from the other fields will be shipped in batches as they are completed. The total cost of a copy of the Atlas will be about $2000.00; the David Dunlap Observatory copy is a gift of the Atkinson Charitable Foundation.

J. F. H.

REVIEW OF PUBLICATIONS

Co-ordination of Galactic Research edited by A. Blaauw (Symposium No. 1 of the International Astronomical Union). Pages viii plus 59; 6¾ × 9¾ in. Cambridge, at the University Press, 1955. Price 7s. 6d.

The purpose of the International Astronomical Union is (1) To facilitate the relations between astronomers of different countries where international co-operation is necessary or useful (2) To promote the study of astronomy in all its departments.

It is therefore particularly appropriate that this first of a new series of symposia organized by the Union should be devoted to the *co-ordination* of research in a broad field. The principal task assigned to the two dozen conferees at Groningen, Netherlands, in June of 1953, was not to listen to progress reports but to formulate the main present problems and to look into the practical questions of how to attack them.

The report of the conference demonstrates that co-ordination is very much to be desired because of the wide variety in the fields of research which bear on galactic problems. Techniques as different as radio astronomy and meridian astronomy are involved. There is a need for survey instruments of the Schmidt type, for the study of individual stars with telescopes of moderate size and for surveys in depth with the largest telescopes. When many techniques and instruments are put to work on a particular class of objects, such as the Cepheids, or on a particular area of the sky, such as the galactic nucleus, the information which can be collected is bound to be much more valuable than what would be obtained from a scattered attack.

The report shows that the conference did not side-step its responsibilities. Particulars are given of the types of stellar objects requiring further study. Areas of the sky are listed in which co-operative programmes will be undertaken. The most suitable types of instruments are discussed. The development of certain promising techniques is encouraged. Estimates are given of the time required for extended programmes, for instance, the search for RR Lyrae variables. Care was taken, however, not to plan programmes in such detail as to destroy an investigator's initiative; the equipment available to an individual will of course govern his attack on each problem. Current research programmes are mentioned in order to avoid duplication and as a guide to results which can be expected in the near future.

As is so often the case, the publication of the proceedings has been somewhat delayed, but work at a number of institutions has already been influenced by these discussions. The Groningen conference will be an important milestone in galactic research, and, it is hoped, a model for future I.A.U. symposia.

D. A. M. R.

Astrophysical Quantities by C. W. Allen. Pages 263; 6¾ × 9½ in. London, University of London, The Athlone Press, 1955. Price 55*s*.

Do you know offhand how many spectroscopic binaries are eclipsing variables? What is the numerical relation between universal time and ephemeris time? Do you need the oscillator strengths of helium lines? Perhaps you did not forget the number of satellites of Uranus hitherto discovered, but you might not remember the dimensions of their orbits. There are well known quantities as the radius of the earth—but you are lost, if it comes to a computation in which you need a decimal in addition to those kept in your memory.

Whenever you discuss your problems of research, when you are preparing lectures, or when you want to be informed on subjects not immediately in your line, you will be greatly helped by *Astrophysical Quantities*. An unexpected amount of information on physical and astronomical constants, dimensions and numerical characteristics is collected in 130 sections dealing with constants and units, atomic quantities, fundamental information concerning spectra, emission and absorption of radiation, the dimensions and physical data of the earth and its atmosphere, the sun, planets and satellites, interplanetary matter, normal stars as well as stars with special characteristics, data from stellar statistics for the surroundings of the sun. Finally there are data pertinent to matter and radiation in interstellar space, stellar clusters, the galaxy as a whole, and the extragalactic nebulae.

There are compilations of data distributed in the literature, but I do not know any other tabulation of this completeness. Many of these figures have not been included in such tables before. This book has a modern point of view and therefore includes information on very recent developments, for example on the different populations in galaxies and clusters with their subdivisions, or results from radio astronomy.

Where necessary the tables are accompanied by comprehensive definitions and basic formulae. One of the most important qualities of the book is that the sources for the data and additional literature are given in each section.

Often astronomers have felt the need of such a collection of tables, and I know many of them—including myself—have been accumulating data in a private card catalogue. I am certain, however, that most of them will prefer to use this book instead of or in addition to their notes. It can be a convenient tool for anyone with some association with astronomy, and it will be worth while to keep it always near at hand.

P. WELLMANN

Silver Domes: Observatories of the World by Claire Inch Moyer. Pages 174; 6 × 9 inches. Denver, Colorado, Big Mountain Press, 1955. Price $6.00.

Astronomers, both professional and amateur, have long felt the need for an up-to-date directory of observatories and astronomers of the world. Such directories have in the past been prepared by the staff of the Royal Observatory of Belgium under the auspices of the International Astronomical Union. The last one of these issued was dated 1931 with a Supplement dated 1936. For many purposes these are now seriously out-of-date, and this fact was recognized at the 1952 Rome Congress of the I.A.U. when a new edition of "Les Observatoires Astronomiques et les Astronomes" was authorized and put in the charge of Dr. F. Rigaux of the Royal Observatory of Belgium. Since 1952 Dr. Rigaux and his colleagues have circulated questionnaires and have completed a provisional manuscript edition. Each observatory listed in the text will now receive a copy of the appropriate pages of this manuscript for correction before the definitive edition is published. About 500 observatories will be included, along with lists of their principal equipment and the astronomers on their staffs. Important private observatories will be included. A great deal of effort will have gone into this compilation, capable judgement will have been used in editing the material and every effort will have been made to correct errors and omissions; the final result will be of very great value.

From the foregoing remarks, it should be clear that preparation of a directory of observatories requires rather special facilities; it is hardly the task to be undertaken by an individual lacking a good knowledge of astronomy and astronomical equipment and lacking the support of a large organization. Yet, the author of "Silver Domes" has undertaken such a task, and the result is, to say the least, unsatisfactory. It is true that the author states in the Preface that "this directory is not a complete list of all the observatories in the world." This is hardly an excuse, however, for omitting the Dominion Observatory, Ottawa, or Tonantzintla in Mexico,

or the Observatory of Oxford University, while devoting page after page to rather dull historical facts about student observatories at various American colleges. "Silver Domes" lists about fifty-eight American observatories and exactly one Russian observatory (Pulkova). It is far from wise, let alone fair, to give the reading public the impression that there are virtually no astronomers in Russia—there are many, and they are making important contributions.

Quite apart from the omissions—which spoil this book's usefulness as a directory—there is little to recommend it. There is no uniformity of style: for some important observatories, for example, Yerkes, there is little given but a terse list of telescopes; for other obscure student observatories there are tedious details of history and construction. There are many errors: simple typographical errors, like "astromonical" on the jacket, the reader can overlook; he may have difficulty, however, figuring out who was Astronomer Royal "Brooley" (page 42) or how La Plata Observatory has concealed the fact that it possesses a telescope of aperture 43 metres (page 169).

A directory must be judged by its completeness and its accuracy. "Silver Domes" unfortunately has neither.

J. F. H.

Periodicity and Variation of Solar (and Lunar) Eclipses by Prof. Dr. van den Bergh. Volume I, pages 263; volume II, 13 diagrams; 7¾ × 10½ in. Haarlem (Holland), H. D. Tjeenk Willink & Zoon, N.V., 1955. Price f 110.00 (Dutch guilders).

This book is a revised translation of an earlier Dutch edition: *Regelmaat en wisselingen bij zonsverduisteringen . . .*, 1951. As the title indicates it deals with periodicities of solar and lunar eclipses as well as with their irregularities.

One can say that the author did a very fine job in analyzing the eclipses of Oppolzer's *Canon der Finsternissen* with a special emphasis on periodicities. In part I an explanation is given of how a period is a combination of a number of synodic and draconic months. The author shows how the natural period, the saros, comes into existence and gives the story of his re-discovery of another period, the inex. It is shown that all eclipses can be arranged in an inex-saros panorama. Also other periods are discussed each being a combination of a number of inex and saros.

Part II deals with the so-called border undulations which are caused by the complicated motion of the moon in its orbit, while in part III it is explained how total, annular or hybrid eclipses come into being. Hybrid

is the term used for eclipses which are annular at sunrise and sunset and total around noontime. One can see how the scheme wonderfully explains all the eclipses in Oppolzer's *Canon*. Moreover, the author has tried to build up an artificial panorama of fictitious eclipses and has shown that they closely resemble those of Oppolzer. A handy addition to the book is a list of Oppolzer's solar and lunar eclipses.

It is worth mentioning that the author has made an exhaustive analysis of eclipses without any recourse to higher mathematics, by a method that anyone can follow easily. The other book by the same author, *Eclipses in the second millenium B.C. etc.*, (*Jour. R.A.S.C.*, vol. 49, p. 208, 1955) is intended to be a practical application of the foregoing to a prediction of eclipses. Graphical representations of the foregoing analyses appear in volume II.

Here are a few formal remarks about the book. This reviewer questions the use of centesimal degrees, for many readers may find it confusing. In Appendix I a few words would have clarified the meaning of the asterisk attached to the type of eclipse. In Oppolzer's *Canon* an asterisk refers to the chart and means that all three main points of an eclipse are depictured on the same chart. As there are no charts included in this book, the asterisk could have been omitted. In Appendix II the time of eclipses is given in Western European Time; this is more conveniently called Universal Time or Greenwich Civil Time. There are a few printing mistakes in the text, which, however, are insignificant.

As has been said already, the book represents a very good treatise on eclipses and one can recommend it to the interested reader.

G. A. B.

MEETINGS OF THE SOCIETY

AT VICTORIA

October 13, 1954—The President, Mr. R. S. Evans, introduced the speaker, Dr. Jean K. McDonald, who spoke on "Ferut, Canada's Electronic Computing Machine". Dr. McDonald reviewed the development of computing machinery, from the first mechanical numeral-wheel machines of 1642 to the present-day automatic sequence-control electronic computing machines. The basic principles of the modern machines are remarkably similar to those suggested in 1835 by Charles Babbage, a Cambridge mathematician, although over 100 years intervened during which technological developments made possible their construction. A detailed description was given of one such machine, Ferut, built by Ferranti Ltd. of Manchester and located at the University of Toronto, with some explanation of its operation through the use of binary numbers. Some instances of the use of Ferut in problems that have arisen in Canadian science and industry were given by the speaker.

F. R. Williams, *Recorder*

November 10, 1954—Summer course members who had joined the Centre as full time members were welcomed by the President, Mr. R. S. Evans. The evening's programme was in charge of Mr. J. L. Muir, Mr. N. Hutchings and Mr. C. Wyatt, with Mr. Muir speaking on the subject "Amateur Telescope Making." Mr. Muir compared the reflector and the refractor as instruments for amateur telescope-makers, pointing out that the building of a reflector involves less work and less cost, and that it will probably give better results. Amateur telescope-makers were advised not to aim too high. A reflecting telescope with 6-inch diameter and 48-inch focal length would provide a very good starting basis. Mr. Muir pointed out that patience, application and determination were required, and went on to describe in detail the various procedures in grinding, polishing, testing and silvering a mirror. Mr. Muir, Mr. Hutchings and Mr. Wyatt showed on the platform not only their own telescopes but a number of pieces of testing apparatus they had made, and they offered their assistance to anyone who wished to make a telescope. Dr. R. M. Petrie, in thanking the three men for their interesting and instructive demonstration, pointed out that these telescopes were not toys but instruments of science, and he emphasized that a strong observing group was a necessary nucleus for any thriving astronomical body.

January 11, 1955—The newly-elected President, Dr. Jean K. McDonald, extended a welcome to new members and described the general pattern of the meetings to them. The speaker of the evening, Dr. K. O. Wright, whose topic was "Eclipses of the Sun", had been in charge of the group that was sent from the Dominion Astrophysical Observatory to set up equipment at Hansen, Ontario, in order to study the total eclipse of the sun on June 30, 1954. Dr. Wright discussed what occurs at the times of partial and total solar eclipse, with a description of the phenomena observable to the astronomer with his special equipment. He described the setting up of the equipment at Hansen, and the observations that would have been made during the

eclipse, had the sky been clear; unfortunately, however, it was completely overcast. Dr. Wright showed a number of beautiful colour slides taken at the site of the eclipse expedition, and at various places in Canada and the United States during his motor trip to Ontario. Dr. J. A. Pearce spoke on current phenomena illustrating with the celestial globe the risings and settings of the various planets. Mr. Evans reported observing several interesting objects, including the Owl Nebula, through a 4-inch refractor. Mr. Hutchings showed a photograph he had taken of the south polar region of the moon.

The President announced that a CBC broadcast would be made at the Dominion Astrophysical Observatory for the programme Canadian Scenes on January 15, 1955. Announcement was made of a special meeting of the Centre on January 26, 1955, at which Dr. Otto Struve would be the speaker.

February 9, 1955—The speaker of the evening was Prof. D. B. McLay of the Physics Department of Victoria College. In introducing his topic of "Radio Astronomy" Prof. McLay described the electromagnetic spectrum, and pointed out that radio astronomy was concerned with the micro-wave region of the spectrum, which lies between the infra-red and the radio wave regions. Prof. McLay illustrated by means of two highly polished metal paraboloidal reflectors the difference in the properties of the waves from a heat source and a light source. He briefly discussed the main differences between radio waves and the micro-waves in their penetration of the ionosphere, and the information that we obtain from such studies. The micro-waves are being used to penetrate interstellar dust patches and to detect large masses of hydrogen in interstellar space. Following a question period, the speaker was thanked by Mr. R. Peters.

Mr. N. Hutchings described the elongation of the planet Mercury with the aid of slides, Mr. Peters spoke of current phenomena including the next lunar occultations, and Mr. Evans described his observations of sun-spots during the past two weeks.

March 9, 1955—Prof. J. B. Warren of the Physics Department of the University of British Columbia was introduced to the meeting by the President. Dr. Warren began his lecture on "Nuclear Astronomy" by a résumé of the early attempts to fix the ages of the earth, dealing at some length with the more recent and considerably more accurate estimates that came from geological studies of the 19th century. He described how the figure of 3×10^9 years was arrived at from studies of radioactive decay of various elements. Dr. Warren then spoke on the energy production in the sun, discussing several suggested nuclear reactions for attaining the terrific temperature of 20,000,000° at its centre. In conclusion, the speaker told the meeting that nuclear physicists are much interested in what is going on in outer space. Furthermore, the study of cosmic rays will present a challenging problem to them for many years. The number of questions asked the lecturer indicated the interest of his audience, and their thanks to him was given by Dr. Petrie.

Mr. Muir spoke briefly on a recently published note of Kuiper's, which dealt with the study of the moon's surface.

April 13, 1955—The speaker of the evening was Mr. Gordon Shaw, who spoke on "Dr. Einstein and the Universe", basing his discussion on the book of that name by L. Barnett. Mr. Shaw began with the concepts of science introduced by Aristotle and by Galileo, and proceeded to the remarkably accurate laws of mechanics set forth by

Newton. By 1900 it was realized that the known laws did not fully describe the phenomena in the realm of the atom, and in intergalactic space, and between that year and 1927 there grew up a new body of theoretical science, dominated by the Quantum Theory of Planck, and by the Theory of Relativity of Einstein. Mr. Shaw discussed the wave and the particle theory of the transfer of radiant energy through space, and experiments devised to test the existence of the hypothetical ether. Further, he discussed the meaning of Einstein's famous equation relating energy, mass and the velocity of light, and he pointed out that astronomical experiments were used as one means of testing the Special Theory of Relativity. Mr. Shaw concluded with some comments on the space-time continuum, according to Einstein. Some well-chosen slides illustrated the velocity-distance scale of the stellar universe. A lively question and discussion period followed the lecture, the thanks of the audience to Mr. Shaw being expressed by Dr. Wright.

Present at the meeting was Dr. Locke, head of the Stellar Physics Division of the Dominion Observatory, Ottawa, and President of the Ottawa Centre, and he conveyed the greetings of the Ottawa group. Members of the Centre were invited by Mr. Peters to visit the Gordon Head Observatory on the evenings of April 15th and 22nd. The President announced that the Summer Evenings with the Stars series would be held during the five Mondays in August. Further, an announcement was made of the forthcoming visit of the Seattle Convention of the Amateur Astronomical League to the Dominion Astrophysical Observatory on July 4th. The meeting concluded with refreshments and a social hour.

N. HUTCHINGS, *Recorder*

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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. L, No. 1 JANUARY-FEBRUARY, 1956 WHOLE No. 418

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Address of Editors: David Dunlap Observatory, Richmond Hill, Ont.

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Subscription to the JOURNAL is included in membership fee.